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REPORT NO T14-86

PSYCHOLOGICAL FACTORS WHICH LIMIT THE ENDURANCE CAPABILITIES OF ARMOR CREWS OPERATING IN A SIMULATED NBC ENVIRONMENT

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

MAY 1986



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ABSTRACT

Factors which limit the performance capabilities of sustained armor operations in simulated conventional and chemical warfare environments were studied. In the simulated chemical warfare environment, extreme symptom and mood changes resulted in medical casualties, combat ineffectiveness, and early termination of all testing. Significant personality differences existed between casualties and survivors. The majority of casualties voluntarily terminated operational duties because of intense symptoms associated with wearing the chemical protective mask and clothing system. These symptoms were manifestations of respiratory and thermal stress.

The views, opinions and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation.

Human subjects participated in this study after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

INTRODUCTION

The deployment of chemical weapons on the battlefield requires U.S. Army personnel to use four Mission Oriented Protective Postures (MOPP) to achieve an appropriate level of individual protection (19). Protection against chemical agents is achieved by the modular wear of increasing levels of encapsulation ranging from the overgarment in MOPP 1 to total encapsulation in MOPP 4 (i.e., overgarment, overboots, mask/hood, and gloves). Although MOPP levels provide varying degrees of passive protection, the relative impermeability of the chemical protective (CP) clothing items may compromise psychological functions, thermal regulation, comfort, and work efficiency.

The wearing of industrial respirators, similar to the Army's CP mask, has been associated with psychological problems relative to tolerance, comfort, and motivation (14) and respiratory difficulties (15). Brooks et al. (3) reported psychological symptoms and behavioral problems in 20 percent of all soldiers wearing MOPP 4 during a chemical warfare field training exercise. Moreover, three soldiers reported panic immediately after donning the CP mask, and manifested hyperventilation, shaking, confusion, fear of dying, and visual distortions. With the exception of Brooks et al. (3), the psychological reactions to wearing CP clothing in realistic, simulated chemical warfare environments, has not been systematically investigated.

Few studies have adequately addressed the interactive effects of CP clothing and thermal stress on cognitive and visual performance. Fine and Kobrick (5) studied the effects of wearing MOPP 4 over eight hours duration on sustained, sedentary military task performance. The results showed that after four to five hours of exposure to a moderately hot environment (91 degrees Fahrenheit) in MOPP 4, performance on cognitively based military tasks began to markedly degrade. Furthermore, Kobrick and Sleeper (12) reported a serious limitation to detecting visual signals while wearing the MOPP 4 system. The degradation in functional vision occurred early and remained throughout the eight hours of testing.

Previous research has thoroughly documented that wearing CP clothing in warm-hot environments impedes evaporative cooling and results in thermal strain and a diminished physical work capacity (6,7,8,9,11,13,22,23). Toner et al. has investigated the effects of CP clothing, thermal stress and auxiliary cooling on tank crew operations in two studies (22,23). One study clearly demonstrated the inability of tank crewmen, in MOPP 4, to tolerate prolonged exposures in a closed-unventilated compartment with the Wet Bulb Globe Temperature (WBGT) index approximately 95 degrees Fahrenheit (22). It was also demonstrated that an auxiliary liquid cooled vest reduced heat stress, enabling crewmen to perform without difficulty. Thermal stress and large decrements in performance, however, were reported without auxiliary cooling. In the second study, Toner et al. (23) determined that vest auxiliary cooling was more effective for crewmen cooling than an air shower. Despite the efficacy of auxiliary cooling in tank crews, the majority of M60 and M1 tanks have not been retrofitted with cooling capabilities. Therefore,

in the near term, armor operations in hot, chemically contaminated environments will likely be conducted without the benefit of auxiliary cooling.

The previous research cited herein, has investigated physiological responses, thermal stress and CP clothing in both laboratory and field studies. On the other hand, there exists a lack of corresponding psychological data. The psychological effects of thermal strain, breathing difficulty, encapsulation-confinement, and the shear mechanical encumbrance of wearing the total MOPP system during sustained operations beyond eight hours creates a combination of stressors which undoubtedly affect the capabilities of tank crews to operate in chemically contaminated areas.

The present study examines psychological factors which limit the endurance capabilities of armor crews operating in simulated conventional and chemical warfare environments.

METHOD

Subjects

Twenty-seven active duty male soldiers served as subjects for the present study. All subjects were instructed to read and sign an informed consent form prior to participation in the study. Subjects were divided into six crews with each crew consisting of four crewmen and a seventh crew consisting of three crewmen. Four crews were assigned to the 1st Platoon and three crews assigned to the 2nd Platoon.

Design

The design consisted of three treatment conditions (MOPP 4, FIX and SUPER) and a control (MOPP 0). MOPP 0 is used throughout this report to indicate a "NO MOPP" condition. Each platoon participated in a standard armor field test at MOPP 0 and repeated the test in MOPP 4, FIX, and SUPER conditions. The MOPP 4 condition consisted of the armor NBC ensemble, including the CP mask (a modified M-25 with the capability of drinking through a hydration tube), rubberized boots, gloves and standard overgarment. The FIX condition was comprised of the same protective clothing ensemble described in the MOPP 4 condition; however, crewmen were permitted to eat, and were trained in various coping strategies designed to mitigate stress. In addition, a different method of hydration, the fist-flex system, was employed during the FIX condition in contrast to the conventional canteen to tube method. The SUPER condition was designed to demonstrate various procedures and material with a limited number of crews. These innovations consisted of one crew without CP mask or gloves, one crew wearing micro-climate cooling vests, and one crew operating in an air-cooled crew compartment. Although the SUPER condition adequately demonstrated these technologies using a small number of crews, variations within the condition resulted in an array of confounding factors which resulted in extraneous systematic variance in psychological measures. Therefore, the analysis was restricted to the MOPP 0, MOPP 4, and FIX conditions. The test

was terminated when two crewmen from a single crew withdrew, either voluntarily or were removed by the medical monitor. These crewmen were regarded as "casualties" and their crew rendered combat ineffective at 50 percent strength. The remaining crewmen, "Survivors", were required to end their participation since their crew was at 50 percent strength. Casualties and survivors were assigned to two post hoc groups, "Casualties" and "Survivors" for comparisons.

Procedure

All field tests were conducted on an armor training range at Fort Knox, KY. A computerized (GRiD COMPASS II, Model 1131) Performance Assessment Battery, developed by the US Army Research Institute of Environmental Medicine (USARIEM), was designed to assess psychological performance changes during armor operations. This battery was administered prior to the start of the field test (pre test administration), at six hour intervals during the field test (operational testing administrations), and at the completion or termination of the field test (post test administration). These test administrations are hereafter referred to as pre test, testing, and post test administrations throughout the report. The Performance Assessment Battery consisted of the Environmental Symptoms Questionnaire (ESQ), the Clyde Mood Scale, State Anxiety Questionnaire, and Crew Atmosphere Questionnaire (crew harmony). A separate computerized (GRiD COMPASS II, Model 1131) Personality Assessment Battery was developed by USARIEM and administered to all crewmen during the medical screening procedure several days prior to the start of the field test. This battery consisted of measures of sensation seeking, locus of control, attitudes toward crew and duty, trait anxiety, self-motivation and depression. The self-motivation test was designed to measure adherence to a self-imposed exercise regimen.

RESULTS

Personality Assessment Battery

Measures of sensation seeking, locus of control, job satisfaction, trait anxiety, self-motivation, and depression were analyzed to reflect differences between casualties and survivors over MOPP 4 and FIX conditions. Means, standard deviations and ranges for all subjects for these personality measures may be found in Table 1. It is important to note that these measures were obtained during medical screening, several days prior to the start of the armor field test when the identity of casualties and survivors were yet to be determined. After completing the armor field test all soldiers were assigned to either the casualty or survivor group, relative to the MOPP 4 or FIX condition, on a post hoc basis. Tables 2 and 3 show descriptive statistics for the personality measures by group for the MOPP 4 and FIX experimental conditions respectively. Casualties were found to exhibit significantly greater depressive tendencies $T = 2.07 (24)$, $p < .05$ and lower self-motivation $T = 2.83 (24)$, $p < .01$ than survivors in the MOPP 4 condition. There were no significant differences between survivors and

casualties from the FIX condition. Depression scores for all soldiers were categorized into two groups; 0-9 were classified as not depressed (N=23) and 20 and above (N=4) classified as moderately depressed for further analysis. Although group sizes are disparate, the data indicates the depressed group was more symptomatic for respiratory distress $F = 9.17 (1,100)$, $p < .003$, mental fatigue $F = 2.22 (1,100)$, $p < .02$, and general fatigue $F = 17.63 (1,100)$, $p < .001$. Furthermore, it is worthy of note that the four soldiers classified as moderately depressed were the only subjects who become casualties during both the MOPP 4 and FIX conditions (i.e., double casualties).

Clyde Mood Scale¹

The Clyde Mood Scale is a 48 item questionnaire designed to assess mood changes associated with changes in central nervous system functions. Individual questions from the Clyde Mood Scale were used to compute factor scores for six factors: comradery, clear thinking, sleepiness, discontentment, aggressiveness, and dizziness. Mood Factor means, standard deviations and ranges are shown in Tables 4, 5, 6, 7, 8 and 9 respectively. Casualties reported significantly more intense feelings of sleepiness $F = 4.73 (1,117)$ $p \leq .05$ and dizziness $F = 9.63 (1,117)$ $p \leq .01$ when compared to survivors. No significant differences existed between survivors and casualties on feelings of comradery, clear thinking, discontentment and aggressiveness. Significant differences among test administrations were found for comradery $F = 5.77 (2,117)$, $p \leq .01$, sleepiness $F = 3.51 (2,117)$, $p \leq .05$, and dizziness $F = 8.28 (2,117)$, $p \leq .01$. Lower feelings of comradery were reported by soldiers during the operational testing administration when compared to the pre or post test administrations. Soldiers progressively experienced more intense feelings of sleepiness and dizziness from the pre test to the post test administrations. The most intense feelings of sleepiness and dizziness were reported during the post test administration. There were no significant differences among MOPP 0, MOPP 4, and FIX conditions on any of the Mood Factors.

Environmental Symptoms Questionnaire (ESQ)

The ESQ is a 41 item questionnaire developed at USARIEM designed to assess psychological perceptions of physiologically based symptoms during exposure to extreme environmental conditions. The ESQ was administered to all crews to ascertain the symptomatology experienced during armor operations in MOPP gear. Seven factors were derived from a 41 question ESQ based on 1500 administrations over several field studies in the PNBC²

1 The Clyde Mood Scale consists of six factors, two of which are not appropriate descriptors to the needs of the Army. These two factor names were changed to more appropriate synonyms. The factor friendly was renamed comradery and unhappy renamed discontentment.

program. The seven factors were labeled respiratory distress, mental fatigue, thermal stress, general fatigue, gastrointestinal distress, muscle exhaustion, and alertness based on factor loadings of individual symptom items. The symptom factor scores are behaviorally anchored with "0" indicating the absence of a symptom, "1" the presence of a symptom of slight intensity, "2" a symptom somewhat intense, "3" a symptom of moderate intensity, "4" considerable symptom intensity, and "5" extreme symptom intensity. Means, standard deviations and ranges for symptom factor scores are presented in Tables 10, 11, 12, 13, 14, 15, and 16 respectively.

Significant differences in symptom intensity was found between survivors and casualties for respiratory distress $F = 13.74$ (1,115), $p < .001$, mental fatigue $F = 7.24$ (1,115), $p < .01$, thermal stress $F = 6.50$ (1,115), $p < .01$, general fatigue $F = 12.43$ (1,115), $p < .001$, gastrointestinal distress $F = 7.56$ (1,115), $p < .01$, and muscle exhaustion $F = 3.82$ (1,115), $p < .05$. There were no differences between casualties and survivors on the alertness factor. Without exception, casualties reported more intense symptoms than survivors in the MOPP 4 and FIX conditions, as illustrated in Figures 1 and 2. The intensity on all ESQ factors significantly differed among administrations. Perceptions of respiratory distress $F = 16.31$ (2,115), $p < .001$, mental fatigue $F = 12.69$ (2,115) $p < .001$, general fatigue $F = 12.75$ (2,115), $p < .001$, gastrointestinal distress $F = 8.78$ (2,115), $p < .001$, and muscle exhaustion $F = 7.15$ (2,115), $p < .001$ progressively increased from pre test values to post test values. Thermal stress showed the greatest symptom intensity during the operational testing administration in contrast to the other symptom factors. Perceptions of alertness progressively degraded from pre test to post test administrations, $F = 5.59$ (2,115), $p < .01$. Duncan's multiple range test revealed significant ($p < .05$) differences for general fatigue, muscle exhaustion and alertness between testing and pre test administrations and between post test and pre test administrations. A comparison of testing and post test administrations for these three factors, however, revealed no significant differences. General fatigue and muscle exhaustion showed significantly greater intensities for the post test administration compared to pre test values. Alertness was significantly lower for post test and testing administrations compared to pre test values. Figure 4 shows symptom factor scores for each of the administration periods. Clearly, greater symptom intensities were manifested after the pre test administration with very little difference between testing and post test administrations. Significant differences were found between the MOPP 4 and FIX conditions for perceptions of respiratory distress $F = 4.03$ (1,115), $p < .05$, mental fatigue $F = 3.91$ (1,115), $p < .05$, muscle exhaustion $F = 5.66$ (1,115), $p < .02$, and general fatigue $F = 7.15$ (1,115), $p < .01$, while thermal stress, gastrointestinal distress and alertness did not significantly vary. All ESQ factors showed subjects to experience more intense symptoms in the MOPP 4 condition compared to the FIX condition (see Figure 3).

Crew Atmosphere Questionnaire

The Crew Atmosphere Questionnaire is a 10 item questionnaire designed to measure each individual crewmember's perception of the crew as a

functional unit. Means, standard deviations and ranges for crew atmosphere (cohesion) are presented in Table 17. A significant difference existed between survivors and casualties $F = 6.49$ (1,87) $p \leq .01$ with survivors showing higher crew atmosphere scores. Crew atmosphere did not significantly vary among test administrations or among NO MOPP, MOPP 4, and FIX conditions.

State Anxiety Questionnaire

The State Anxiety Questionnaire is a 20 statement survey designed to assess situational influences on anxiety. Means, standard deviations and ranges for state anxiety are shown in Table 18. Casualties exhibited a significantly greater level of anxiety when compared to survivors, $F = 7.21$ (1,117) $p \leq .01$. The level of anxiety significantly varied among test administrations $F = 5.93$ (2,117) $p \leq .01$. Anxiety experienced during operational testing was significantly greater than pre test values. State anxiety scores did not significantly vary among NO MOPP, MOPP 4 and FIX conditions.

TABLE 1

MEANS, STANDARD DEVIATIONS, AND RANGES FOR PERSONALITY
ASSESSMENT BATTERY (N=26)

<u>Attribute</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
Depression	5.62	8.58	0	27	27
Attitudes Toward Crew Duty	54.00	8.59	36	69	33
Attitudes Toward Supervisor	82.19	15.68	52	104	52
Attitudes Toward Pay	17.42	4.32	3	25	17
Attitudes Toward Promotion	16.73	4.26	5	25	20
Attitudes Toward Members of Crew	67.58	15.51	24	91	67
Total Crew Attitude	237.92	37.16	144	297	153
Sensation Seeking	21.07	5.80	8	32	24
Locus of Control	14.23	3.68	7	20	13
Trait Anxiety	38.89	10.36	22	56	34
Self Motivation	29.53	9.32	12.56	46.33	33.77

TABLE 2

MEANS, STANDARD DEVIATIONS, AND RANGES FOR
PERSONALITY ASSESSMENT BATTERY UNDER MOPP 4 CONDITION FOR
SURVIVORS (N=14), AND CASUALTIES (N=12)

<u>Attribute</u>	<u>Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
Depression	Survivors	2.46	3.28	0	12	12
	Casualties	9.42	11.23	0	27	27
Attitudes Toward Crew Duty	Survivors	54.23	8.48	36	69	33
	Casualties	53.17	9.17	36	69	33
Attitudes Toward Supervisor	Survivors	82.38	14.13	58	103	45
	Casualties	80.25	17.25	52	104	52
Attitudes Toward Pay	Survivors	18.39	4.41	10	25	15
	Casualties	16.08	4.12	8	22	14
Attitudes Toward Promotion	Survivors	16.69	4.17	6	23	17
	Casualties	16.17	5.44	5	25	20
Attitudes Toward Members of Crew	Survivors	70.54	12.32	51	91	40
	Casualties	63.08	18.08	24	91	67
Total Crew Attitude	Survivors	242.23	34.19	189	292	103
	Casualties	228.75	38.52	144	297	153
Sensation Seeking	Survivors	20.92	5.88	12	32	20
	Casualties	21.25	6.23	8	30	22
Locus of Control	Survivors	14.77	3.24	9	20	11
	Casualties	13.92	4.32	7	20	13
Trait Anxiety	Survivors	37.08	9.58	22	53	31
	Casualties	41.83	10.85	22	56	34
Self Motivation	Survivors	33.36	8.25	20.10	46.33	26.23
	Casualties	23.96	8.24	12.56	37.95	25.39

TABLE 3

MEANS, STANDARD DEVIATIONS, AND RANGES FOR
PERSONALITY ASSESSMENT BATTERY UNDER FIX CONDITION FOR
SURVIVORS (N=14) AND CASUALTIES (N=10)

<u>Attribute</u>	<u>Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
Depression	Survivors	3.31	3.23	0	12	12
	Casualties	7.60	11.48	0	27	27
Attitudes Toward Crew Duty	Survivors	53.85	7.02	43	63	33
	Casualties	53.90	10.69	36	69	20
Attitudes Toward Supervisor	Survivors	86.46	13.54	58	103	45
	Casualties	74.70	18.05	52	104	52
Attitudes Toward Pay	Survivors	16.69	4.79	8	23	15
	Casualties	17.00	3.62	10	22	12
Attitudes Toward Promotion	Survivors	17.92	4.92	6	24	18
	Casualties	15.90	5.09	5	25	20
Attitudes Toward Members of Crew	Survivors	68.38	14.56	42	91	49
	Casualties	67.90	18.25	24	91	67
Total Crew Attitude	Survivors	243.31	33.21	189	292	103
	Casualties	230.10	44.53	144	297	153
Sensation Seeking	Survivors	20.31	4.57	12	32	20
	Casualties	23.60	6.19	12	32	20
Locus of Control	Survivors	13.92	3.33	7	19	12
	Casualties	14.50	4.04	9	20	11
Trait Anxiety	Survivors	38.62	9.54	27	53	26
	Casualties	39.00	10.59	22	56	34
Self Motivation	Survivors	30.52	9.93	13.82	37.95	25.39
	Casualties	28.00	8.98	12.56	46.33	32.51

TABLE 4

MEANS, STANDARD DEVIATIONS, AND RANGES FOR
CLYDE-MOOD FACTOR OF COMRADERY

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	46.32	13.47	18.56	76.22	57.66
Pre-test	49.64	12.84	20.98	76.22	55.26
Testing	39.78	11.51	22.08	64.62	42.55
Post-test	46.66	14.03	18.56	75.43	56.88
NO MOPP (N=26)	50.59	13.34	19.13	76.12	56.98
MOPP 4 (N=26)	46.39	14.14	18.96	76.22	57.26
FIX (N=24)	46.26	12.94	18.56	75.38	56.83
Survivors (N=28)	47.81	14.51	18.56	76.22	57.66
Casualties (N=20)	44.58	12.60	20.95	75.38	54.33
PRE-TEST					
MOPP 4 Survivors (N=14)	50.30	15.64			
Casualties (N=12)	48.63	12.72			
FIX Survivors (N=14)	51.81	11.42			
Casualties (N=10)	48.62	13.83			
TESTING					
MOPP 4 Survivors (N=14)	34.19	7.96			
Casualties (N=12)	39.68	13.82			
FIX Survivors (N=14)	41.97	11.78			
Casualties (N=10)	40.73	11.88			
POST-TEST					
MOPP 4 Survivors (N=14)	53.93	16.24			
Casualties (N=12)	42.95	11.16			
FIX Survivors (N=14)	46.59	13.20			
Casualties (N=10)	42.45	14.95			

TABLE 5

MEANS, STANDARD DEVIATIONS, AND RANGES FOR CLYDE-MOOD
FACTOR OF CLEAR-THINKING

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	51.24	8.02	30.55	72.76	42.21
Pre-Test	52.91	7.09	36.79	72.76	35.97
Testing	50.70	8.07	30.72	67.31	36.59
Post-Test	49.88	8.69	30.55	69.03	38.48
NO MOPP (N=26)	55.22	10.16	40.67	86.46	45.82
MOPP 4 (N=26)	51.88	7.82	34.67	72.76	38.12
FIX (N=24)	50.68	8.22	30.55	70.31	39.76
Survivors (N=28)	51.61	8.11	30.72	72.76	42.04
Casualties (N=20)	50.64	7.98	30.55	69.83	38.48
PRE-TEST					
MOPP 4					
Survivors (N=14)	53.87	8.03			
Casualties (N=12)	54.04	5.30			
FIX					
Survivors (N=14)	52.36	9.54			
Casualties (N=10)	51.65	6.29			
TESTING					
MOPP 4					
Survivors (N=14)	54.57	9.86			
Casualties (N=12)	50.39	7.40			
FIX					
Survivors (N=14)	47.06	8.35			
Casualties (N=12)	53.45	6.04			
POST-TEST					
MOPP 4					
Survivors (N=14)	51.64	6.49			
Casualties (N=12)	48.23	7.66			
FIX					
Survivors (N=14)	51.33	7.18			
Casualties (N=10)	46.57	10.05			

TABLE 6

MEANS, STANDARD DEVIATIONS, AND RANGES FOR
CLYDE-MOOD FACTOR OF SLEEPINESS

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	57.75	12.85	37.08	93.26	56.18
Pre-Test	55.00	12.51	38.99	93.26	54.28
Testing	57.03	9.91	40.81	91.33	50.82
Post-Test	60.90	14.11	37.08	88.71	51.63
NO MOPP (N=26)	55.89	11.29	38.72	93.97	55.26
MOPP 4 (N=26)	59.88	14.97	38.03	93.26	55.24
FIX (N=24)	55.78	9.80	37.08	80.03	42.95
Survivors (N=28)	54.85	9.80	37.08	80.03	42.95
Casualties (N=20)	60.36	14.97	38.03	93.26	55.24
PRE-TEST					
MOPP 4					
Survivors (N=14)	51.08	10.25			
Casualties (N=12)	60.40	16.83			
FIX					
Survivors (N=14)	54.58	9.04			
Casualties (N=10)	50.88	9.60			
TESTING					
MOPP 4					
Survivors (N=14)	58.85	8.72			
Casualties (N=12)	63.94	12.89			
FIX					
Survivors (N=14)	51.64	7.34			
Casualties (N=10)	56.55	7.31			
POST-TEST					
MOPP 4					
Survivors (N=14)	57.67	14.15			
Casualties (N=12)	65.89	16.20			
FIX					
Survivors (N=14)	56.84	7.29			
Casualties (N=10)	63.26	17.30			

TABLE 7

MEANS, STANDARD DEVIATIONS, AND RANGES FOR
CLYDE-MOOD FACTOR OF DISCONTENTMENT

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	38.92	5.27	25.35	61.97	36.62
Pre-Test	38.50	5.28	26.31	61.97	35.67
Testing	39.61	5.32	30.84	49.64	18.80
Post-Test	38.98	5.30	25.35	54.08	28.73
NO MOPP (N=26)	39.57	5.12	31.10	55.41	24.32
MOPP 4 (N=26)	38.92	5.96	25.53	61.97	36.62
FIX (N=24)	38.92	4.59	27.64	50.87	23.25
Survivors (N=28)	39.56	5.04	31.08	61.97	30.90
Casualties (N=20)	38.30	5.59	25.38	54.08	28.73
PRE-TEST					
MOPP 4	Survivors (N=14)	41.12	7.20		
	Casualties (N=12)	37.26	4.47		
FIX	Survivors (N=14)	39.05	5.53		
	Casualties (N=10)	37.09	3.78		
TESTING					
MOPP 4	Survivors (N=14)	38.01	3.66		
	Casualties (N=12)	39.29	7.38		
FIX	Survivors (N=14)	39.46	4.15		
	Casualties (N=10)	41.26	6.09		
POST-TEST					
MOPP 4	Survivors (N=14)	38.80	4.45		
	Casualties (N=12)	39.18	7.36		
FIX	Survivors (N=14)	40.01	4.46		
	Casualties (N=10)	37.30	4.34		

TABLE 8
MEANS, STANDARD DEVIATIONS, AND RANGES FOR
CLYDE-MOOD FACTOR OF AGGRESSIVENESS

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	51.62	9.21	37.49	81.85	44.36
Pre-Test	52.96	9.64	27.49	81.85	44.36
Testing	51.37	9.75	38.08	64.62	39.41
Post-Test	50.44	8.43	37.64	75.45	37.81
NO MOPP (N=26)	55.22	10.16	40.64	86.46	45.82
MOPP 4 (N=26)	52.31	9.47	37.64	81.85	44.21
FIX (N=24)	51.16	9.00	37.49	81.75	44.25
Survivors (N=28)	50.56	8.18	37.49	81.75	44.25
Casualties (N=20)	52.40	10.00	39.12	81.85	4.21
PRE-TEST					
MOPP 4	Survivors (N=14)	50.36	6.19		
	Casualties (N=12)	54.37	11.73		
FIX	Survivors (N=14)	54.81	10.85		
	Casualties (N=12)	50.50	7.40		
TESTING					
MOPP 4	Survivors (N=14)	48.61	5.48		
	Casualties (N=12)	56.23	11.91		
FIX	Survivors (N=14)	48.21	6.92		
	Casualties (N=10)	53.00	12.51		
POST-TEST					
MOPP 4	Survivors (N=14)	48.08	6.37		
	Casualties (N=12)	53.42	10.26		
FIX	Survivors (N=14)	57.24	9.47		
	Casualties (N=10)	47.56	5.70		

TABLE 9
MEANS, STANDARD DEVIATIONS, AND RANGES
FOR CLYDE-MOOD FACTOR OF DIZZINESS

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	53.57	13.13	3.32	54.08	92.20
Pre-Test	49.26	9.71	34.14	79.70	49.57
Testing	52.97	10.07	32.55	87.84	55.28
Post-Test	58.21	15.97	3.32	95.51	92.20
NO MOPP (N=26)	49.48	9.49	37.92	83.76	45.84
MOPP 4 (N=26)	54.36	13.26	32.55	95.51	62.96
FIX (N=24)	52.86	13.07	3.32	89.71	86.39
Survivors (N=28)	49.85	7.77	34.14	76.46	42.32
Casualties (N=20)	57.68	15.74	3.32	95.51	92.20
PRE-TEST					
MOPP 4 Survivors (N=14)	44.22	4.79			
Casualties (N=12)	52.37	11.12			
FIX Survivors (N=14)	47.98	5.61			
Casualties (N=12)	49.60	9.64			
TESTING					
MOPP 4 Survivors (N=14)	50.44	7.79			
Casualties (N=12)	50.44	11.22			
FIX Survivors (N=14)	50.67	4.68			
Casualties (N=12)	60.60	13.60			
POST-TEST					
MOPP 4 Survivors (N=14)	53.60	9.84			
Casualties (N=12)	67.37	15.17			
FIX Survivors (N=14)	52.32	9.44			
Casualties (N=10)	59.63	23.35			

TABLE 10

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF RESPIRATORY
DISTRESS BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>highest</u>	<u>Range</u>
TOTAL	.83	.95	0	5.00	5.00
Pre-Test	.32	.53	0	2.29	2.29
Testing	.93	1.04	0	5.00	5.00
Post-Test	1.24	1.00	0	4.42	4.42
MOPP 4 (N=26)	1.03	1.11	0	5.00	5.00
FIX (N=24)	.64	.74	0	3.71	3.71
Survivors (N=28)	.53	.51	0	2.29	2.29
Casualties (N=22)	1.12	1.18	0	5.00	5.00
PRE-TEST					
MOPP 4 Survivors (N=14)	.26	.31			
Casualties (N=12)	.59	.69			
FIX Survivors (N=14)	.29	.62			
Casualties (N=10)	.11	.16			
TESTING					
MOPP 4 Survivors (N=14)	.47	.42			
Casualties (N=12)	1.52	1.78			
FIX Survivors (N=14)	.89	.58			
Casualties (N=10)	.58	.34			
POST-TEST					
MOPP 4 Survivors (N=14)	.76	.37			
Casualties (N=12)	2.03	1.07			
FIX Survivors (N=14)	.50	.35			
Casualties (N=10)	1.53	1.02			

TABLE 11

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF MENTAL FATIGUE
BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	.66	.91	0	5.00	5.00
Pre-Test	.20	.48	0	2.15	2.15
Testing	.86	1.08	0	5.00	5.00
Post-Test	.99	.95	0	3.56	3.56
MOPP 4 (N=26)	.83	1.05	0	5.00	5.00
FIX (N=24)	.51	.73	0	3.56	3.56
Survivors (N=28)	.45	.60	0	2.30	2.30
Casualties (N=27)	.88	1.10	0	5.00	5.00
PRE-TEST					
MOPP 4					
Survivors (N=14)	.25	.67			
Casualties (N=12)	.29	.39			
FIX					
Survivors (N=14)	.24	.58			
Casualties (N=10)	.01	.03			
TESTING					
MOPP 4					
Survivors (N=14)	.49	.50			
Casualties (N=12)	1.55	1.80			
FIX					
Survivors (N=14)	.79	.60			
Casualties (N=10)	.39	.32			
POST-TEST					
MOPP 4					
Survivors (N=14)	.71	.70			
Casualties (N=12)	1.51	1.00			
FIX					
Survivors (N=14)	.29	.33			
Casualties (N=10)	1.37	1.05			

TABLE 12

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF THERMAL
STRESS BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	1.21	1.09	0	5.00	5.00
Pre-Test	.42	.51	0	2.41	2.41
Testing	1.75	1.03	0	5.00	5.00
Post-Test	1.65	1.09	0	4.07	4.07
MOPP 4 (N=26)	1.39	1.22	0	5.00	5.00
FIX (N=24)	1.06	.92	0	3.26	3.25
Survivors (N=28)	1.01	.85	0	2.96	2.96
Casualties (N=22)	1.42	1.25	0	5.00	5.00
PRE-TEST					
MOPP 4 Survivors (N=14)	.52	.68			
Casualties (N=12)	.41	.44			
FIX Survivors (N=14)	.40	.56			
Casualties (N=10)	.36	.39			
TESTING					
MOPP 4 Survivors (N=14)	1.34	.61			
Casualties (N=12)	2.32	1.60			
FIX Survivors (N=14)	1.57	.83			
Casualties (N=10)	1.65	.29			
POST-TEST					
MOPP 4 Survivors (N=14)	1.62	.86			
Casualties (N=12)	2.17	1.23			
FIX Survivors (N=14)	.89	.66			
Casualties (N=10)	1.88	1.12			

TABLE 13

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF GENERAL FATIGUE
BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	1.11	.96	0	5.00	5.00
Pre-Test	.62	.63	0	2.38	2.38
Testing	1.30	1.04	0	5.00	5.00
Post-Test	1.45	.98	0	4.32	4.32
MOPP 4 (N=26)	1.36	1.11	0	5.00	5.00
FIX (N=24)	.87	.71	0	2.98	2.98
Survivors (N=28)	.82	.58	0	2.30	2.30
Casualties (N=22)	1.39	1.15	0	5.00	5.00
PRE-TEST					
MOPP 4 Survivors (N=14)	.60	.54			
Casualties (N=12)	.93	.70			
FIX Survivors (N=14)	.49	.58			
Casualties (N=10)	.44	.63			
TESTING					
MOPP 4 Survivors (N=14)	.89	.63			
Casualties (N=12)	2.02	1.66			
FIX Survivors (N=14)	1.11	.59			
Casualties (N=10)	1.05	.54			
POST-TEST					
MOPP 4 Survivors (N=14)	1.16	.50			
Casualties (N=12)	2.18	1.20			
FIX Survivors (N=14)	.75	.49			
Casualties (N=10)	1.55	.80			

TABLE 14

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF GASTROINTESTINAL
DISTRESS BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	.51	.82	0	5.00	5.00
Pre-Test	.16	.42	0	2.00	2.00
Testing	.60	.95	0	5.00	5.00
Post-Test	.79	.92	0	3.25	3.25
MOPP 4 (N=26)	.61	.92	0	5.00	5.00
FIX (N=24)	.41	.71	0	3.25	3.25
Survivors (N=28)	.30	.46	0	2.00	2.00
Casualties (N=22)	.72	1.03	0	5.00	5.00
PRE-TEST					
MOPP 4 Survivors (N=14)	.07	.09			
Casualties (N=12)	.29	.54			
FIX Survivors (N=14)	.22	.59			
Casualties (N=10)	.01	.03			
TESTING					
MOPP 4 Survivors (N=14)	.38	.25			
Casualties (N=12)	1.07	1.71			
FIX Survivors (N=14)	.49	.50			
Casualties (N=10)	.35	.29			
POST-TEST					
MOPP 4 Survivors (N=14)	.46	.53			
Casualties (N=12)	1.19	.97			
FIX Survivors (N=14)	.23	.39			
Casualties (N=10)	1.22	1.17			

TABLE 15

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF MUSCLE
EXHAUSTION BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	.53	.70	0	5.00	5.00
Pre-Test	.24	.39	0	2.05	2.05
Testing	.65	.96	0	5.00	5.00
Post-Test	.73	.67	0	2.74	2.74
MOPP 4 (N=26)	.69	.85	0	5.00	5.00
FIX (N=24)	.38	.49	0	2.09	2.09
Survivors (N=28)	.40	.46	0	2.05	2.05
Casualties (N=22)	.66	.86	0	2.05	2.05
PRE-TEST					
MOPP 4					
Survivors (N=14)	.26	.37			
Casualties (N=12)	.30	.32			
FIX					
Survivors (N=14)	.22	.55			
Casualties (N=10)	.15	.27			
TESTING					
MOPP 4					
Survivors (N=14)	.30	.22			
Casualties (N=12)	1.21	1.66			
FIX					
Survivors (N=14)	.66	.51			
Casualties (N=10)	.19	.13			
POST-TEST					
MOPP 4					
Survivors (N=14)	.67	.49			
Casualties (N=12)	1.17	.82			
FIX					
Survivors (N=14)	.27	.26			
Casualties (N=10)	.73	.63			

TABLE 16

MEANS, STANDARD DEVIATIONS, AND RANGES FOR ESQ FACTOR OF ALERTNESS
BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	2.24	1.46	0	5	5
Pre-Test	2.81	1.48	0	5	5
Testing	1.89	1.19	0	5	5
Post-Test	1.91	1.46	0	5	5
MOPP 4 (N=25)	2.27	1.34	0	5	5
FIX (N=24)	2.21	1.57	0	5	5
Survivors (N=28)	2.48	1.50	0	5	5
Casualties (N=22)	2.00	1.40	0	5	5
PRE-TEST					
MOPP 4 Survivors (N=14)	3.10	1.29			
Casualties (N=12)	2.34	1.38			
FIX Survivors (N=14)	3.17	1.71			
Casualties (N=10)	2.73	1.49			
TESTING					
MOPP 4 Survivors (N=14)	2.32	.76			
Casualties (N=12)	2.38	1.60			
FIX Survivors (N=14)	1.46	.94			
Casualties (N=10)	1.67	1.16			
POST-TEST					
MOPP 4 Survivors (N=14)	2.64	1.22			
Casualties (N=12)	1.30	1.02			
FIX Survivors (N=14)	2.15	1.83			
Casualties (N=10)	1.73	1.49			

TABLE 17

MEANS, STANDARD DEVIATIONS, AND RANGES FOR CREW ATMOSPHERE SCORES
BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	37.69	6.05	22	50	28
Pre-Test	38.23	6.30	27	50	23
Testing	37.32	6.61	22	50	28
Post-Test	37.58	6.62	24	50	26
NO MOPP (N=26)	37.86	5.70	28	50	22
MOPP 4 (N=26)	37.78	6.66	26	50	24
FIX	37.43	6.88	26	50	24
Survivors (N=28)	38.30	6.50	22	50	28
Casualties (N=22)	36.20	6.70	26	50	24
PRE-TEST					
MOPP 4 Survivors (N=14)	40.78	5.87			
Casualties (N=12)	36.63	6.61			
FIX Survivors (N=14)	39.69	6.70			
Casualties (N=10)	34.50	5.09			
TESTING					
MOPP 4 Survivors (N=14)	32.80	4.09			
Casualties (N=12)	35.00	5.10			
FIX Survivors (N=14)	38.14	9.79			
Casualties (N=10)	34.50	6.95			
POST TEST					
MOPP 4 Survivors (N=14)	40.85	6.30			
Casualties (N=12)	35.60	7.53			
FIX Survivors (N=14)	38.92	6.97			
Casualties (N=10)	32.88	5.19			

TABLE 18

MEANS, STANDARD DEVIATIONS, AND RANGES FOR STATE ANXIETY SCORES
BY CONDITION, ADMINISTRATION, AND GROUP

<u>Condition/Group</u>	<u>Mean</u>	<u>S.D.</u>	<u>Lowest</u>	<u>Highest</u>	<u>Range</u>
TOTAL	55.66	9.80	37	88	51
Pre-Test	53.06	9.64	38	76	38
Testing	57.35	8.35	40	72	32
Post-Test	56.15	10.63	37	88	51
NO MOPP (N=26)	54.25	9.72	37	83	46
MOPP 4 (N=26)	57.41	10.37	40	88	48
FIX	55.03	9.16	38	72	34
Survivors (N=28)	53.97	9.32	37	83	46
Casualties (N=22)	58.48	10.00	40	88	48
PRE-TEST					
MOPP 4	Survivors (N=14)	52.73	10.28		
	Casualties (N=12)	57.60	11.25		
FIX	Survivors (N=14)	49.50	7.87		
	Casualties (N=10)	51.25	7.03		
TESTING					
MOPP 4	Survivors (N=14)	56.20	4.21		
	Casualties (N=12)	62.14	9.14		
FIX	Survivors (N=14)	61.70	7.57		
	Casualties (N=10)	60.42	5.32		
POST-TEST					
MOPP 4	Survivors (N=14)	52.18	9.32		
	Casualties (N=12)	62.67	11.57		
FIX	Survivors (N=14)	52.67	10.82		
	Casualties (N=10)	58.00	8.59		

DISCUSSION

The results of the present study are consistent with the findings of previous research investigating psychological factors associated with wearing industrial respirators, environmental stress, and exercise. Psychological problems effecting endurance in MOPP 4 were primarily associated with thermal and respiratory distress. The present results support previous findings from both military (3) and industrial (15) populations indicating that the perception of respiratory distress or discomfort, imposed by wearing the CP mask or industrial respirator, is an important factor which limits work tolerance or endurance. Brooks et al. (3) indicated that reactions to donning the CP mask, in a subpopulation of soldiers, were manifested by anxiety, panic and hyperventilatory responses characteristic of a psychophysiological phenomenon known as "hyperventilation syndrome." Of obvious military relevance is the fact that published research on this syndrome dates back to Da Costa's classic report involving "soldier's heart" in 1871 (4). Highly stressful environments, such as combat, impedance to normal breathing, hypoxia, heat and exercise seem to initiate hyperventilatory responses in individuals who are hypersensitive to these stressors.

Findings from the current study also support published data from the industrial literature on work tolerance, anxiety and depression (18). Indications are that high anxiety soldiers have an increased tendency or are at a greater risk for experiencing distress - primarily respiratory - from wearing the CP mask and hood. Depression was also found to be an important factor contributing to MOPP 4 endurance and in particular to sensitivity to the CP mask. High depression scores indicated a greater risk for experiencing respiratory distress and becoming a casualty. Representative of this finding is the recognition from previous research that 10 percent of any given sample of non-hospitalized individuals who volunteer to participate in exercise experiments are found to manifest psychological problems such as depression and anxiety (14,16). The severity of depression and anxiety has been found to correlate inversely with perception of effort (10), CO₂ sensitivity (21) and work tolerance (14). The finding that soldiers classified in the moderately depressed group experienced greater respiratory distress, mental fatigue, and general fatigue and were more representative of the casualty group reinforces the conclusions of previous work (1,2), indicating that the cognitions of depressed individuals are negatively toned, unrealistic and distorted. Depressives maintain distorted conclusions by failing to utilize potentially corrective feedback from the environment; that is, their beliefs are impervious to contradictory information. Soldiers with greater depressive tendencies may misperceive or misevaluate their tolerance to stressors from the operational environment. The notion of erroneous cognitions that are impervious to environmental feedback may account for the finding that casualties are significantly more symptomatic than survivors, but the symptomatology is manifested only after experiencing operational stress and is not apparent in pre testing. The greater depressive tendencies shown by the casualty group, with negatively toned cognitions characteristic of depression, may account for their significantly lower crew atmosphere scores in contrast to survivors.

Morgan (16,17) reported that hyperventilation, which normally occurs in response to vigorous exercise and/or increased core temperature, can also occur in some individuals for no apparent reason. Specifically, certain types of individuals are hypersensitive to exercise, heat, elevated PCO₂, lactate production, and hypoxia. These individuals grossly hyperventilate when stressed and their ventilatory responses seem to exceed normal physiological demand. Moreover, hyperventilation, and the resultant physiological changes, have been associated with decrements in psychomotor performance and increased error rates. The present findings indicate that some soldiers terminate their operational duties in MOPP 4 because they experience intense symptoms associated with wearing the CP mask and hood. These symptoms are mostly manifestations of thermal and respiratory distress. Other crewmembers under identical condition did not experience symptoms of such intensity. Consequently, there is a subpopulation of soldiers who are predisposed to experience distress while wearing MOPP 4. These soldiers would be at far greater risk when placed in stressful environments and would undoubtedly compromise mission performance.

It is important to consider an additional point when interpreting the results of the present study using volunteer subjects. Rohles et al. (20) reported psychological differences between subjects volunteering for a thermal stress study and those electing not to volunteer. All of the low anxiety subjects volunteered for a thermal stress investigation but none of the high anxiety subjects volunteered. The subpopulation of soldier volunteers for the present study may not be representative of the armor crew population. Moreover, it is reasonable to conclude that the incidence of psychological problems experienced with MOPP 4 in the present study represents an underestimate of the pervasiveness of the problem since most of the high risk (high anxiety) soldiers are not inclined to volunteer.

The psychological problems experienced while wearing MOPP 4 and specifically the CP mask should be particularly responsive to training interventions. Indeed, the finding in the present study that symptoms in the FIX condition were significantly less intense compared to the MOPP 4 condition may be a serendipitous result attributed to an order effect in the test design. Since all crews performed first in the MOPP 4 condition and repeated testing in the FIX condition the additional time spent in MOPP 4 could have mitigated the operational stress in the subsequent FIX condition. The training effect was confounded, however, with the employment of coping strategies, the use of the "fist flex" hydration system, and the opportunity to eat during the FIX condition.

Future studies should pursue the development of a psychological screening instrument to identify soldiers who experience extreme psychological problems, and in particular to identify those soldiers who experience excessive respiratory distress, while wearing the CP mask. Training programs for soldiers hypersensitive to MOPP 4 distress should be developed in the laboratory and validated in the field. These training programs can be modified to enhance MOPP 4 endurance for all soldiers.

Models should be developed to predict MOPP 4 casualties, and possibly endurance times, based on psychological factors. Finally, psychophysiological factors should be researched which elucidate mechanisms of respiratory distress, claustrophobia, and other variables related to MOPP 4 intolerance.

FIGURE 1. POST TEST MEANS
OF ESQ FACTORS BY GROUP
FOR MOPP 4 CONDITION

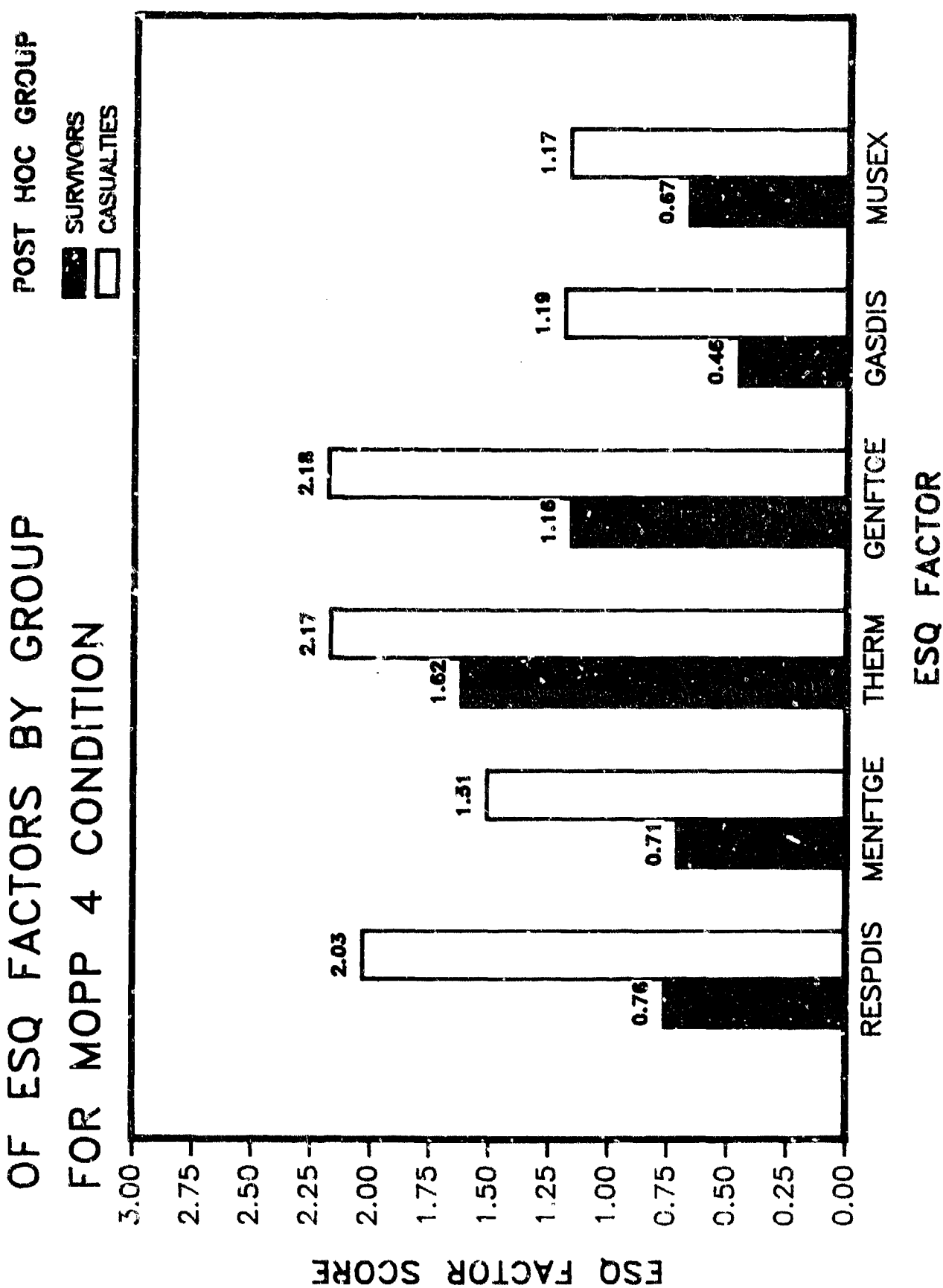


FIGURE 2. POST TEST MEANS
OF ESQ FACTORS BY GROUP
FOR FIX CONDITION

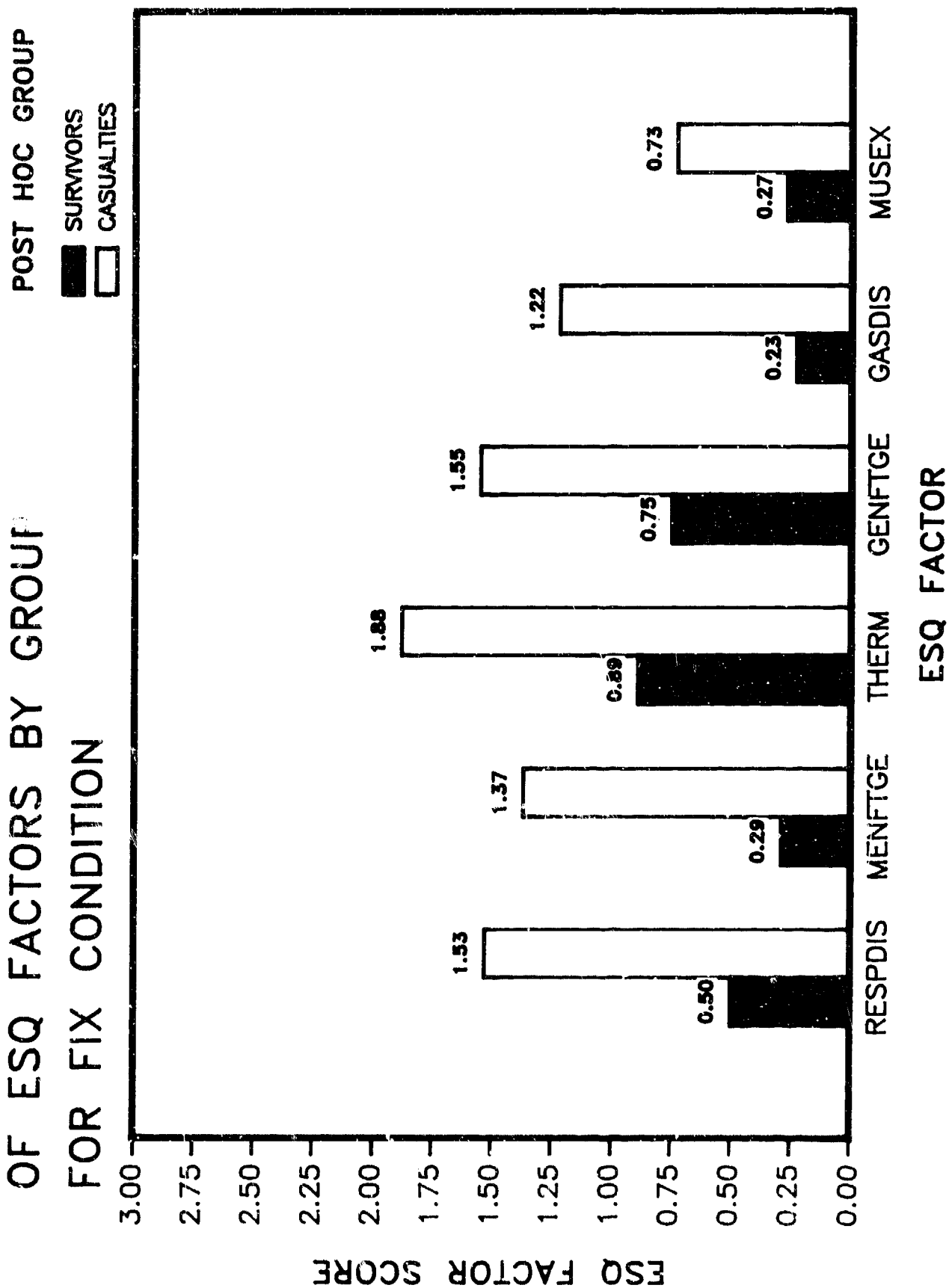


FIGURE 3. MEANS OF ESQ
FACTORS BY CONDITION
FOR FIX CONDITION

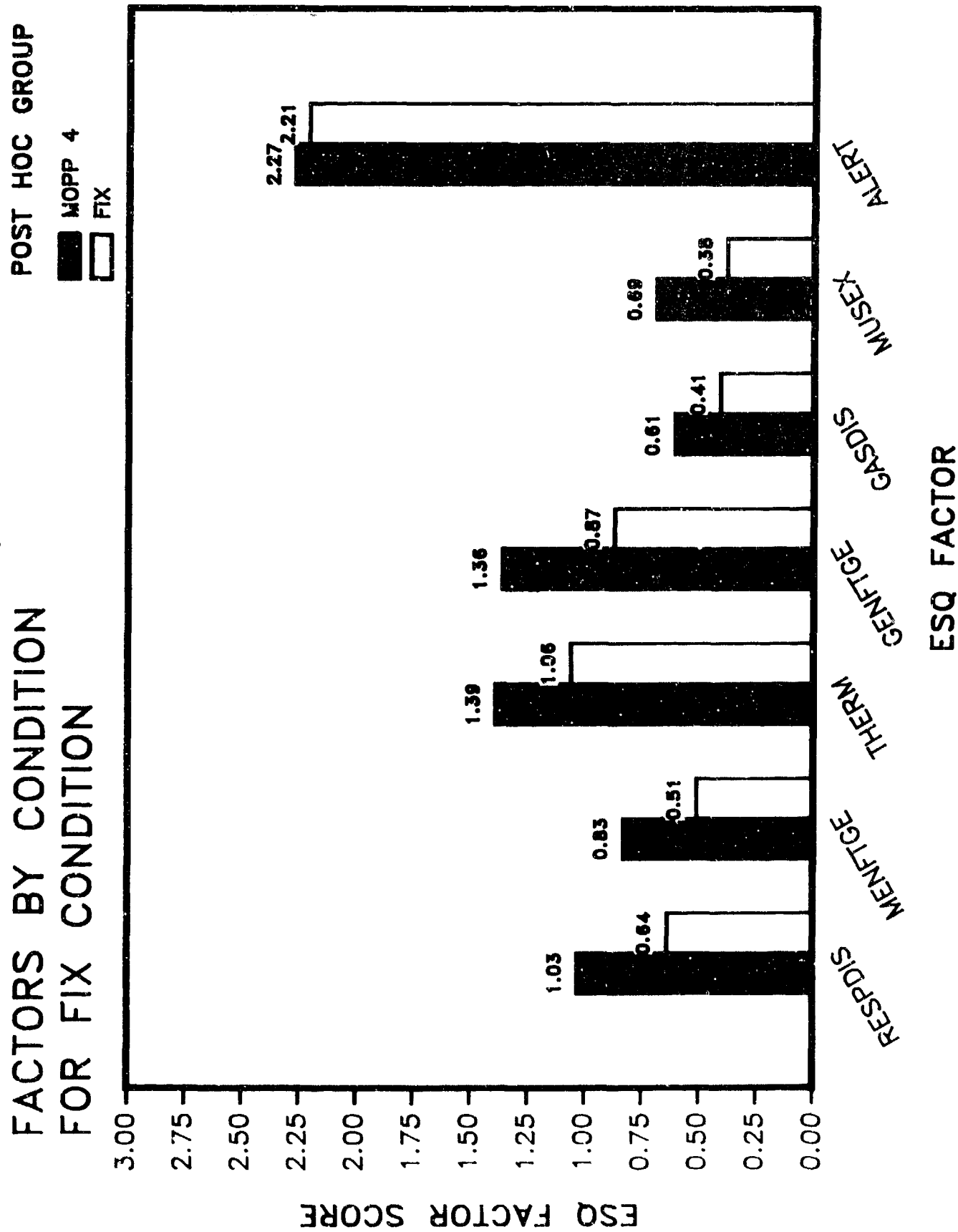
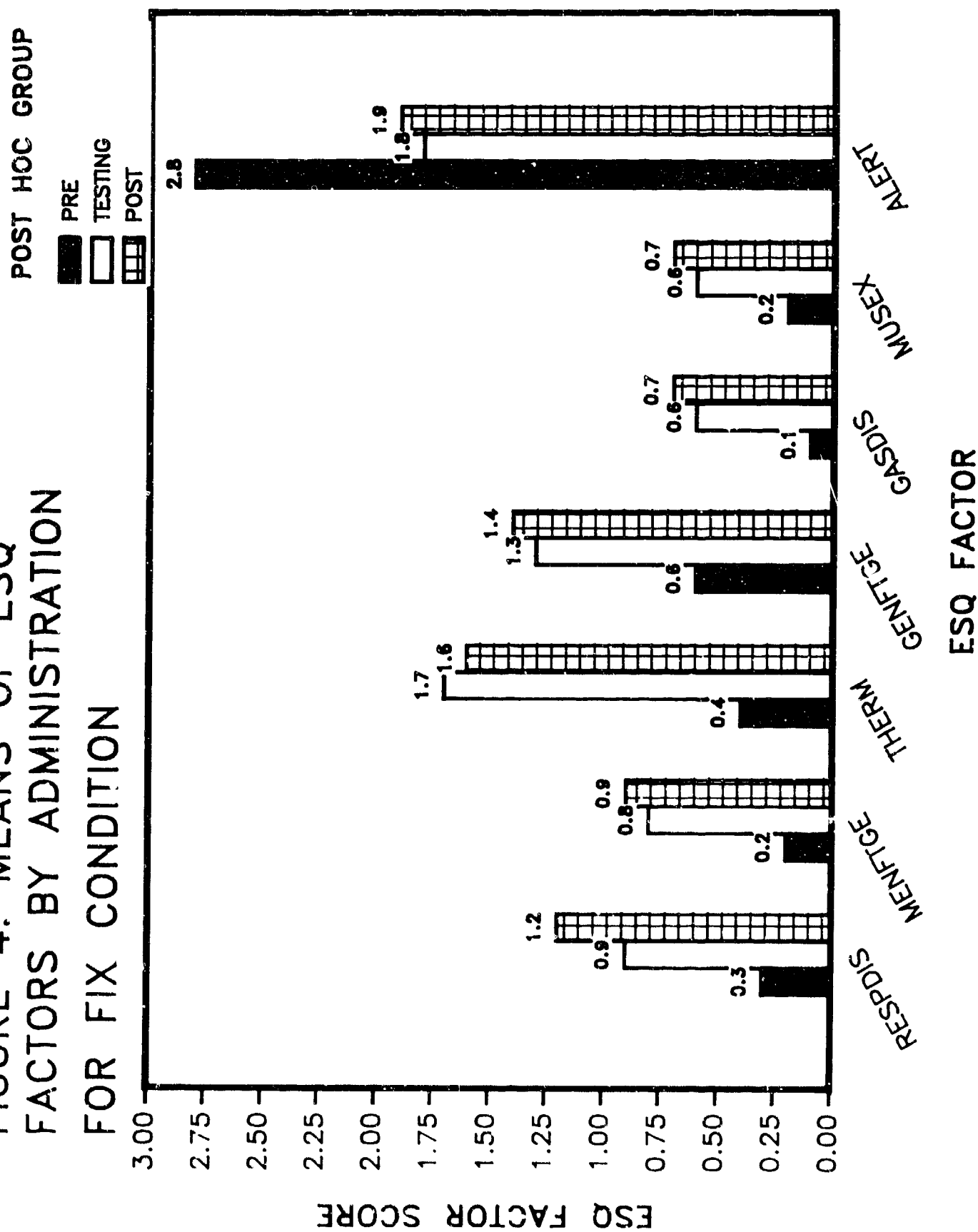


FIGURE 4. MEANS OF ESQ
FACTORS BY ADMINISTRATION
FOR FIX CONDITION



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